ABUNDANCE OF ANTARCTIC JUVENILE FISHES ON SOFT-BOTTOM SUBSTRATES : THE IMPORTANCE OF THE REFUGE (1)

by

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ABSTRACT. – By means of scuba diving and with an experimental design which simulates the heterogeneity created by the empty shells of *Laternula elliptica* over soft bottom areas in South Bay (Palmer Archipelago, Antarctica), the authors demonstrate that the gregarious distribution and the abundance of juvenile fishes (*Pagothenia borchgrevinki* and *Notothenia (Gobionotothen gibberifrons)* are related to some causes of the mortality of the bivalve (e.g. plowing by icebergs or predation by starfishes).

RÉSUMÉ. – Grâce à des plongées sous-marines et au moyen d'une dispositif expérimental simulant l'hétérogénéité due aux coquilles vides de *Laternula elliptica* sur les fonds mous de South Bay (Archipel Palmer, Antarctique), les auteurs montrent que la distribution grégaire et l'abondance des juvéniles de *Pagothenia borchgrevinki* et de *Notothenia (Gobionotothen) gibberifrons* sont liées à certaines causes de la mortalité du bivalve, par exemple le labourage par les icebergs ou la prédation par les étoiles de mer.

During the recent years we have conducted a series of submarine observations to determine the way in which fishes obtain their food and how they escape predation by utilizing different refuges (Moreno & Zamorano, 1979 ; Moreno, 1980 ; Duarte & Moreno, 1981). On the basis of these observations we hypothesize that the actual habitat used by the fishes (adults and juveniles) is the result of food searching activity and the way by which they escape predators (other fishes, birds or seals). Bottoms with a greater environmental heterogeneity have greater fish density and diversity. This escape from predation in environmentally heterogeneous areas is also demonstrated by experimental studies conducted in soft bottom communities (Woodin, 1978).

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Our study site, South Bay, Palmer Archipelago (64°52’24”S, 63°36’W) has different kinds of bottoms, which provide a gradient in environmental heterogeneity, from rocky bottoms to soft bottoms of sand and mud. There is a good correlation between heterogeneity and fish species density (Moreno *et al.* 1977). In the shallow soft bottoms, only juveniles of some species are found in low density and there are fewer fishes in this type of bottom than in the rocky bottoms. In this paper we show that fish density is depending on complex ecological parameters including physical and biological factors.

Observations in natural conditions

During the Antarctic summer of 1981 (January-February) we dived for almost 25 hours over soft bottoms between 10 and 20 meters depth. At these immersions we observed empty shells of the bivalve *Laternula elliptica* on the bottom with juvenile fishes inside. To quantify the abundance of these fishes, two transects in two different areas were completed. One of the transects included 10 quadrats of 2 x 2 meters, the other 15 quadrats of equal size.

Because of the low density of fishes, the quadrats of the two transects were grouped. Results of these observations can be seen in Table I. Only 3 quadrats had shells and fishes, in different densities, showing a tendency towards aggregation. According to Poole (1974), when the population consists of groups with different individual numbers, it’s possible to use an index derived by Morisita (1959) to have a quantitative measurement of aggregation. In our case the value of the aggregation index = 5.2 is highly significative.

TABLE I. – Number of empty shells of *Laternula* and number of juvenile fishes in 25 quadrats of 2 x 2 m sampled over soft bottom areas at South Bay, between 10 and 20 m depth.

No. Squares	Number of Shells	Number of Fishes*	Frequency (%)
1	15	5	33.3
2	20	9	40.5
3	12	4	33.3
4	0	0	0
↓	↓	↓	↓
25	0	0	0

* = *Pagothenia borchgrevinki* (Boulenger)

Experimental observations

The benthic community on the shallow soft bottom is dominated by the bivalve *Laternula elliptica*. The empty shells of this bivalve are used as a refuge by juvenile fishes to escape predators, especially diving marine birds like the blue-eye shag and penguins (Schlatter & Moreno, 1976). Normally there are aggregations of shells on the soft bottom. If aggregations of fishes are a result of shell aggregations, we hypothesized that with artificial aggregations of shells, we could obtain aggregations of juvenile fishes.

On a flat bottom area without *Laternula* shells and fishes, we installed 2 square plots with 25 shells in each one, each shell being at a distance of 50 cm from one of the other. After 15 days, the frequency of occupied shells was 17.8 and 28.6 % in each plot (Table II).

We also simulated «*Laternula* type heterogeneity» by placinq plastic tubes (diameter : 2.5 cm - length : 15 cm), buried obliquely 5 cm in the bottom. Four plots of 25 tubes each were installed in different areas of the bottom. Interval between tubes in each plot was 50 cm. In these four artificial bottoms, frequencies of fishes were found between 8.3 to 30 % (Table III).

TABLE II. – Results of two experimental plots with shells of *Laternula*. (Number of shells correspond to those that remained after 15 days).

No. Squares	Number of Shells	Number of Fishes*	Frequency (%)
1	7	2	28.6
2	23	4	17.8

* = *Notothenia gibberifrons* Lonnberg

TABLE III. – Results of four experimental plots resembling heterogeneity created by *Laternula* with plastic tubes buried obliquely in the bottom. (Number of tubes are those that remained after 15 days).

No. Squares	Number of Tubes	Number of Fishes	Frequency (%)
1	21	4 *	19.5
2	23	2 **	9.1
3	24	2 *	8.3
4	20	6 *	30.0

* = *P. borchgrevinki*

** = *P. borchgrevinki* and *N. gibberifrons*

The juvenile specimens collected in these preliminary experiments were : *Pagothenia borchgrevinki* (75.8 %) and *Notothenia (Gobiotothen) gibberifrons* (24.2 %). Gruzov (1977) and Hoshiai (1980) mention that schools of *P. borchgrevinki* refuge under stones in shallow and intertidal waters. The behaviour observed at South Bay seems to be analogous, but refuge is supplied by the empty shells of *Laternula*. We observed that sometimes the fishes swim around their shelter, but whenever a diver goes closer, the fishes take refuge into the shells. Probably once the refuge problem is solved, their permanence in the area depends on food availability, duration of the valves joined together or fish size.

In spite of the intensive sampling using different fishing methods in this area, we have never collected adult of *Pagothenia borchgrevinki*, probably because of the cryopelagic habit of this species (Andriashev, 1970). Nevertheless *Notothenia gibberifrons* appears abundantly in this area (Moreno & Osorio, 1977).

Discussion

If fishes concentrate in the shell aggregations as shown in the former results, the question is, how do the *Laternula* empty shell aggregations form ?

According to our observations it seems that there are two complementary mechanisms. One of them is physical and unpredictable. When icebergs drift over the shallow soft bottom they can plow a furrow in there, and in fact we observed areas that were impacted by the iceberg, noting a great quantity of crushed and intact specimens of *Laternula*. Analogous situations, with complete destruction of the macrofauna, have been described by Richardson & Hedgpeth (1977). The intact bivalves remain on the surface, apparently unable to bury in the substrate, until they are eaten (Kauffman, 1974 ; Zinsmeister, 1976). We have seen the voracious Asteroids *Labidiaster annulatus* and the small red starfish *Odontaster validus* consuming *Laternula*. These mechanisms may produce the aggregation of empty shells which can be potentially used as a refuge by juvenile fishes.

The association of iceberg plowing together with asteroid predation seems to be responsible of the abundance of juveniles on the shallow soft-bottom at South Bay. We think it is necessary to develop more experiments in order to evaluate the magnitude of these ecological relations.

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